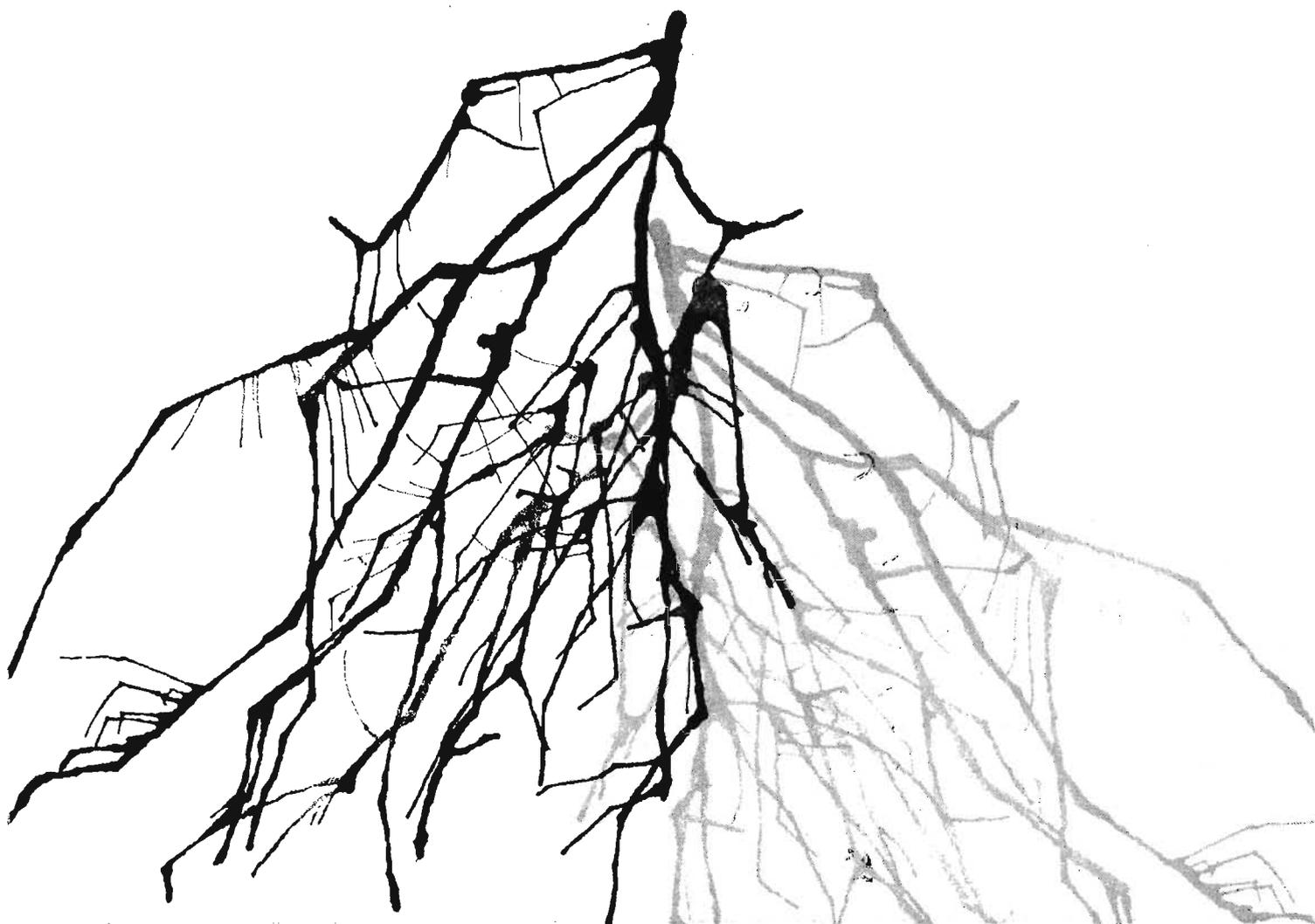


BETTER ROOTSTOCKS FOR CITRUS GROWN IN HAWAII

R. A. Hamilton, C. L. Chia, P. J. Ito

HITAHR · COLLEGE OF TROPICAL AGRICULTURE AND HUMAN RESOURCES · UNIVERSITY OF HAWAII



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THE AUTHORS

R. A. Hamilton is Emeritus Professor of Horticulture, College of Tropical Agriculture and Human Resources, University of Hawaii.

C. L. Chia is Extension Specialist in Horticulture, College of Tropical Agriculture and Human Resources, University of Hawaii.

P. J. Ito is Professor of Horticulture, College of Tropical Agriculture and Human Resources, University of Hawaii.

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BETTER ROOTSTOCKS FOR CITRUS GROWN IN HAWAII

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INTRODUCTION

Citrus fruits have been grown in Hawaii since 1792, when seeds of the so-called Hawaiian orange were introduced from Capetown, South Africa, by Captain George Vancouver. This same type of orange has been known on Hawaii as the Kona orange, on Oahu as the Waiialua orange, and on Kauai as the Waimea orange. Since this original introduction, thousands of citrus trees of several different species have been grown in home fruit gardens. Numerous small, semicommercial plantings of tangerines, limes, and oranges have been made, but acreages have remained small; at present there are only about 120 acres of commercial orange plantings and 25 acres of tangerines in the State.

In the past, very little attention was paid to selecting the most suitable rootstocks for citrus. A large proportion of the citrus trees in the State are either seedlings or air-layered trees. In Hawaii, citrus has usually been grown on rootstocks chosen for convenience or by circumstances, rather than for desirable or useful qualities. In recent years Troyer citrange, Cleopatra mandarin, Swingle citrumelo, and several other rootstocks have been tried in Hawaii although there has been little or no experience or background information on their performance.

Citrus rootstocks are important because they influence disease resistance, tree vigor, productivity, and quality of fruit produced. It is only common sense and good judgment to use the best rootstocks available in new or replacement home plantings, as well as in commercial orchards. Because of the usual difficulty in marketing Island-grown citrus fruit, any means of improving quality and marketability would be desirable and worthwhile.

The use of disease-resistant or tolerant rootstocks is definitely advisable as a protective measure against gummosis, or gumming disease, commonly a serious problem on citrus grown on heavy soils or under conditions of high rainfall and humidity. Gummosis, also known as foot rot, is caused by

soilborne fungi (*Phytophthora* spp.), which attack the tree near ground level (see Figure 1). Because of this, resistant rootstocks should be used whenever possible, and nursery stock should always be grafted 12 to 18 inches above ground level to provide maximum protection.

Resistance to "tristeza" virus is also extremely important because a severe strain of this disease is widespread in Hawaii. Tristeza strains have been introduced repeatedly in citrus nursery stock imported from the U.S. Mainland and the Orient. Tristeza, often referred to as "quick decline," is a virus infection that results in the blocking or interference of conducting tissue at the graft union of susceptible scion/rootstock combinations. Decline, dieback, and a general unhealthy condition of the tree are usual symptoms of tristeza. When a section of bark is removed, pitting or pitted furrows usually can be found in the wood of trees suffering from tristeza (see Figure 2). Rootstocks resistant or tolerant to tristeza are considered the most effective protection against this disease (see Figure 3).

According to evidence accumulated to date, rootstocks proposed in Table 1 appear most satisfactory for citrus in Hawaii. A dozen or more other rootstocks listed in Table 2 have been tested in experimental plantings in the State, but to date have not proved promising enough to be recommended.

Rough lemon and pummelo seedlings are generally unsatisfactory rootstocks for tangerines and oranges, and the four rootstocks listed in Table 1 are suggested as being more suitable. Orange and tangerine trees grown on rough lemon roots are susceptible to gummosis, especially on heavy soils or in high-rainfall areas. In general, they produce fruit lower in sugar content and coarser in texture than those grown on rootstocks recommended in Table 1. Pummelo seedlings are frequently incompatible with other citrus species, and therefore do not make satisfactory rootstocks for citrus cultivars.



Figure 1. Advanced stage of gummosis on sweet orange.

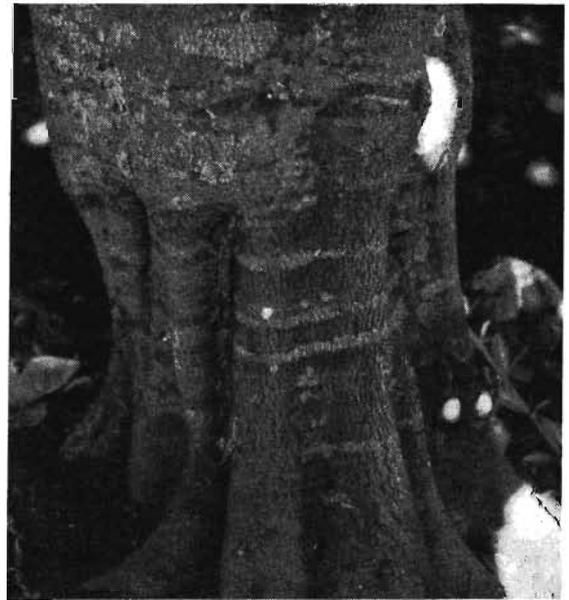


Figure 3. A strong, disease-resistant graft union of Chun pummelo grafted on Heen Naran rootstock.



Figure 2. Kusaie lime branches with bark removed. Left, from a disease-free tree. Right, from a tree affected by tristeza. Note pitted furrows in wood.

Up to now, competition from imported oranges has placed locally grown oranges at a disadvantage in Island markets. This trend can be expected to continue unless the quality and appearance of Island-grown oranges are markedly improved. Even with good rootstocks, improved fertilizer practices, and a suitable spray program, high quality oranges rarely can be produced in Hawaii because of climatic limitations. As in other areas with a mild tropical climate, it is seldom possible to produce top quality, highly colored oranges with a desirable ratio of sweetness to acidity. This is because the mild, uniform Island climate is generally not conducive to the development of well colored, high quality oranges competitive with California-grown fruit. However, the use of well adapted, disease-resistant rootstocks to improve the quality of citrus fruit produced in Hawaii still deserves consideration by nurserymen and home gardeners. Table 1 lists the best rootstocks tested to date for citrus cultivars commonly grown in the State. These four rootstocks have been tested extensively in rootstock trials at Malama Ki on Hawaii and at Poamoho on Oahu, and have given relatively good results.

Table 1. Rootstocks recommended for citrus fruits in Hawaii

Type of citrus fruit propagated	Suitable rootstocks
1. Tangerine (<i>Citrus reticulata</i>)	Cleopatra, Heen Naran, Rangpur, and Citrus sunki
2. Orange (<i>Citrus sinensis</i>)	Cleopatra, Heen Naran, Rangpur, and Citrus sunki
3. Grapefruit (<i>Citrus paradisi</i>)	Cleopatra, Rangpur, and Heen Naran
4. Lime (<i>Citrus aurantifolia</i>)	Shekwasha, Heen Naran, and ungrafted seedlings
5. Pummelo (<i>Citrus grandis</i>)	Heen Naran and air-layered trees

CHARACTERISTICS OF RECOMMENDED ROOTSTOCKS

The following information on specific properties of particular rootstocks discusses objectionable features and limitations of various rootstocks used now and in the past.

Cleopatra Mandarin (*C. reshni* Hort. ex Tan.)

Cleopatra mandarin is a small-fruited, sour tangerine that is an excellent all-around rootstock, particularly for tangerines and sweet oranges. Cleopatra is resistant to both tristeza virus and gummosis and appears to be widely adapted to Hawaiian soils. Trees grafted on Cleopatra generally grow well and produce good quality fruit on a variety of soils. It is considered a good, safe, disease-resistant rootstock for citrus in Hawaii, and in general has given dependable results. Although Cleopatra seedlings are relatively slow growing in the nursery, they grow fast enough in Hawaii so that seedlings large enough for grafting or budding can be produced within one year.

Heen Naran (*C. lycopersicaeformis* Hort. ex Tan.)

Heen Naran is a type of seedy tangerine, native to Ceylon. It makes an excellent rootstock for tangerines and most oranges in Hawaii. Heen Naran is resistant to tristeza, foot rot, and gummosis. The fruit quality of oranges and tangerines grafted on Heen Naran is above average and the trees are productive and long-lived. Trees of most cultivars grafted on Heen Naran are slightly dwarfed, producing trees about three-fourths as large as standard sized trees. This characteristic is usually preferred for dooryard and home garden planting. Heen Naran is an excellent rootstock for Washington Navel oranges but not for Valencias.

Heen Naran grows well on *aa* lava soils as well as on heavier clay and loam soils. It is a good all-around rootstock for tangerines, grapefruits, pummelos, limes, and most oranges.

Rangpur Lime (*C. limonia* Osbeck)

Rangpur lime is a vigorous, dependable, disease-resistant rootstock for the usual citrus cultivars grown in Hawaii. Rangpur is a vigorous rootstock producing full sized trees resistant to foot rot, gummosis, and tristeza. Rangpur lime is not a true lime but is related more to mandarins; sometimes it develops stem pitting symptoms although this does not appear to adversely affect its performance as a rootstock. Orange and tangerine trees grown on

Rangpur are productive and produce fruit of good quality. Rangpur is widely adapted to a range of soil types, and its seedlings are vigorous and fast growing in the nursery.

Sunki (*C. sunki* Hort. ex Tan.)

Sunki is a small-fruited mandarin relative with inedible, acid fruits. It has given very good results as a rootstock for most oranges and mandarins. Trees grafted on Sunki are characteristically dwarfed but set good crops of better than average quality fruit on trees that are usually no more than half the size of standard sized citrus trees. Trees grafted on Sunki are highly resistant to foot rot, gummosis, and tristeza, the most serious diseases of citrus in Hawaii. Although it takes several months longer to produce Sunki rootstocks, the compact, productive trees produced are well worth the effort. Its disease resistance and improvement in fruit quality make Sunki a very desirable rootstock for the citrus cultivars commonly grown in Hawaii.

Seedling Citrus Trees

In the past, many individual trees, as well as a few small commercial plantings of tangerines and oranges, have been grown from ungrafted seedlings, particularly in the Puna, Kona, and Pahoia districts of the island of Hawaii. It is possible to do this because most citrus cultivars come relatively true from seed. This can be explained by the fact that citrus seeds, unlike the seeds of most tree fruits, have the property of developing several vegetative or non-hybrid embryos in each seed. Such seeds are known as "polyembryonic" or "nucellar" seeds, and produce relatively uniform, true-to-type seedlings. Nucellar seedlings tend to be more vigorous and thorny than grafted trees of the same variety, and they have an additional disadvantage in taking several years longer to come into bearing. However, if off-type and weaker-growing seedlings are eliminated in the nursery, almost all of the remaining seedlings are dependably true to variety.

A notable exception to this is found in pummelos, also called "shaddock," "jabon," and in Tahiti, "pumpelmous." The so-called Tahitian pumpelmous is actually a thin-skinned pummelo. Regardless of the name used, pummelos have monoembryonic seeds with sexual embryos, so that every seedling produced is different. Hundreds of seedling pummelos have been planted in Hawaii, but unfortunately they vary so widely in type, quality, and

flavor of fruit produced that most of them are of little value. This is because the fruit of the seedling pummelos is seldom as good as fruit from the variety that the seed came from. Seedling pummelo trees seldom produce good quality fruit and are useful mainly as ornamental trees. A few selected pummelo trees producing better than average fruit have been selected in Hawaii and are sometimes propagated by air-layering.

Limes, on the other hand, are highly polyembryonic and can easily be propagated true to type from seed. The so-called Chinese, Mexican, or Key limes, as well as Rangpur-type limes, come true from seed, and seedling trees come into bearing within three to four years. Air-layered and grafted lime trees have no real advantage over seedlings except for seedless varieties such as Tahitian or Persian limes, which must be grafted. Lime seedlings have a significant advantage over grafted or air-layered limes because they are initially free from virus diseases.

Air-layered Citrus Trees

Desirable orange, tangerine, lime, and pummelo trees are frequently air-layered by home gardeners to provide planting stock of desired cultivars. Air-layered tangerine trees generally perform satisfactorily and are more suitable for orchard planting than air-layered oranges or limes, which are usually slower growing than seedlings or well-known grafted trees.

A major disadvantage of air-layered citrus plants, compared to grafted trees, is that air-layering does not permit the use of tristeza- and gummosis-resistant rootstocks when own-rooted trees of the variety are susceptible to these diseases.

Propagating citrus trees by air-layering is also slow, laborious, and inefficient compared to budding or grafting on vigorous seedling rootstocks with well-developed root systems. There is no advantage in air-layering over cheaper, faster, and easier methods of grafting or budding on well-grown seedling rootstocks.

OTHER ROOTSTOCKS

There are many rootstocks on which citrus varieties can be grafted, and probably 20 or more different rootstocks have been introduced and tried in Hawaii. At least 17 citrus rootstocks, which have been introduced and tested by University of Hawaii horticulturists over the years, are presently not recommended for use in the State. These rootstocks have been tested for about 20 years at the University of Hawaii's Malama Ki and Poamoho experiment stations. On the basis of these tests plus additional observations and evaluations made in nurseries and in the field, the four rootstocks described and listed in Table 1 are recommended, while 17 others listed in Table 2 are not presently recommended. Reasons for rejecting the rootstocks listed in Table 2 are various and include susceptibility to fungus or virus diseases, stock/scion incompatibility, unsatisfactory growth in the nursery or field, marginal fruit quality, and poor adaptation to soil and climatic conditions in Hawaii.

Although choice of rootstocks is known to be important in citrus, it should be understood that no rootstock can be expected to make up for limitations in temperature and sunlight necessary to develop optimum fruit quality. In areas where temperatures rarely fall below 55°F or rise above 85°F, skin color and sugar content of oranges and tangerines are characteristically less satisfactory than in areas where higher temperatures and wider

Table 2. Citrus rootstocks not recommended for use in Hawaii

1. Rough lemon	10. <i>Citrus volkameriana</i>
2. Troyer citrange	11. <i>Citrus taiwanica</i>
3. Carizzo citrange	12. <i>Citrus aurantifolia</i>
4. Sweet orange	13. <i>Citrus hystrix</i>
5. Trifoliolate orange	14. Sour orange
6. Grapefruit	15. <i>Swinglea glutinosa</i>
7. Pummelo	16. <i>Atalantia citrioides</i>
8. Swingle citrumelo	17. Siamelo
9. <i>Citrus amblicarpa</i>	

temperature fluctuations exist. This is especially true of oranges grown in most home garden plantings and small semicommercial orchards in Hawaii, which seldom produce well-colored fruit of optimum sweetness, acidity, and sugar/acid ratio. Tangerines, however, are more adaptable than oranges to mild Island climates. Tangerines of acceptable appearance and satisfactory quality are produced in selected locations on all islands.

Temperature patterns and other limiting climatic factors need to be kept in mind when choosing sites suitable for planting citrus in Hawaii and deciding on the feasibility of possible commercial plantings.

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